Vol. 12, Part 3. 15th March, 1937.

THE
PROCEEDINGS
OF THE
ROYAL
ENTOMOLOGICAL SOCIETY
OF
LONDON

Series A.
GENERAL ENTOMOLOGY

LONDON:
PUBLISHED BY THE SOCIETY AND
SOLD AT ITS ROOMS, 41, QUEEN'S GATE, S.W.7

Price 3s. 0d.

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INSECTS CAPTURED IN THE FLOWERS OF *NYMPHAEA CAPENSIS* THUNB.

By G. Fox-Wilson, N.D.H., F.R.E.S., F.L.S.

In July, 1935, my attention was drawn by my colleague, Mr. F. C. Brown, to the presence of dead insects in the open blossoms of the Blue Water-lily, *Nymphaea capensis* Thunb. Five plants of this Water-lily are grown in a heated open tank on the lawn in front of the Laboratories at the Royal Horticultural Society's Gardens, Wisley, Surrey.

A series of observations carried out during August, 1935, showed clearly that the phenomenon was of frequent occurrence, and it was uncommon to find a single open blossom without its complement of dead insects. The insects collected during that month were shown at a meeting of the Scientific Committee of the Royal Horticultural Society on the 14th January, 1936 (6).

A review of the literature revealed the fact that this phenomenon has been recorded by several authors, some of whom attributed the death of the insects to mere drowning (Conard, 3, Robertson, 11), others to the confinement of the insects by occlusion of the flower (Bacon, 1), to asphyxiation from the heavy odour of the blossom (Delphino, 5), while Robertson (11) states that Planchon (10) attributed death to the accumulation of carbon dioxide in the floral cup.

Preliminary observations carried out at Wisley appeared to indicate that Robertson's theory was correct. Later, however, it was clear that while many of the smaller insects, for instance, some Syrphids and *Halictus* species, were actually drowned, this theory did not appear to apply to the more robust insects, namely, *Eristalis tenax* Linn., *E. arbustorum* Linn. (fig. 1), *Callicera aenea* F., *Syrphus ribesii* Linn., and *Rhingia campestris* Mg., owing to the shallowness of the liquid in the stigmatic basin. The percentage of total captures of such a robust insect as *E. arbustorum* was, for instance, 61 per cent. in 1935, and 22 per cent. in 1936.

The other suggestions, namely that the insects were either asphyxiated by the heavy odour of the blossom; were confined by occlusion of the flower; or were overcome by the accumulation of carbon dioxide, were considered improbable, though each suggestion was given due consideration during the observations, which were carried out during August, 1935, and from June to October, 1936.

The Plant—Nymphaea capensis Thunb. (= *N. caerulea* (4)) is known as the Cape Blue Water-lily. Its distribution is throughout South and East Africa, Madagascar, and the Comoro Islands (Conard, 3).

Some considerable confusion in nomenclature exists, for this species is referred to as *N. stellata* Willd. (the Blue Lotus of India or the Larger-flowered Starred Water-lily) in Cape collections and by many botanists, while there are others who consider that *N. capensis* is merely a varietal form of *N. stellata*. Bailey (2) sounds a note of warning when he states : " In reading of aquatics prior to 1900, it is well to remember that many British botanists include all blue Water-lilies of the Eastern hemisphere (or all except the Australian forms) under the name *N. stellata*." Again, "*N. caerulea* of B.M. 552 (4) and *N. scutifolia* D.C. are really *N. capensis*." There are, however, a number of forms of both species, while many hybrids have been raised and are grown in various parts of the world.

The flowers are a rich sky blue, 6–8 inches across, and are open four days from 9 a.m. to 6 p.m. (Summer time). The petals number 20–30, and the sepals are pure green outside and whitish within. The stamens, which number about 150, stand in a compact circle close to the petals. The pistil has a broad, concave depression or bowl—the stigmatic basin—in the centre of the flower. It is surrounded by a ring of fleshy, claw-like processes—the carpellary styles—and has a small conical summit at its centre (fig. 2). A large drop of liquid (1·2–1·8 c.c.) is held in the basin when the flower opens, and disappears on the second day, *i.e.* after a period of 24–36 hours, following the opening of the blossom. The flowers are, according to Robertson (11), female on the first day and male for two to three days after.

The flowers open in the morning sun and close in the late afternoon, and stand some 8–12 inches above water level (fig. 3) so that they are protected from crawling insects, with the exception of the Galerucellid, *Galerucella nymphaeae* Linn., and the aphid, *Rhopalosiphum nymphaeae* Linn., both of which occur occasionally on the flowers when in bud and fully open, and upon the flower stems, which they ascend either from the leaves which may completely surround the flower stems, or by crawling on to the buds before upward growth commences.

The plants require warm water—a minimum winter temperature of 55° F., while the summer temperature frequently reaches 85° F.—and are grown in a tank heated with hot-water pipes. The flowering period at Wisley is from the end of June to mid-October.

The Insect Visitors.—Conard (3) states that mining bees and flower-flies are the only insects found in the blossoms of *Nymphaea odorata* Ait. and *N. tuberosa* Paine, while, he says, "in a single bloom of *N. capensis* × *zanzibarensis* Casp., I counted thirty-two little bees."

Bacon (1) under the title "Insects destroyed by Vegetables," says, "I also found that our common Pond-lily (*Nymphaea odorata*) closed up, every now and then, confining insects of various sorts, and that, when the flower was mature, the straight scape would become spiral and draw flower and insects under water."

Robertson (11) gives a detailed account of the occurrence of dead insects in the flowers of *Nymphaea tuberosa* Paine in S. Illinois, and, as his observations agree in the most part with those made on *N. capensis* at Wisley, a review of his paper is desirable. He states that all of the insects were in search of the copious pollen, which the numerous stamens yield in abundance, and that no true nectar is secreted.

The earliest flowers to open each day are the older ones in which pollen is plentiful and in which the stigma is dry. The insects fly from flower to flower in safety gathering their loads. When an hour later the new flowers open with their receptive stigmas, the insects are well dusted with pollen, thereby ensuring pollination. The insects in coming from the older flowers drop in through the narrow opening of the new flowers and rush in with confident haste into the stigmatic basin. If, in their attempts to escape, they trust their weight to the inner stamens, these bend so suddenly as to throw them again into the liquid. If the insect does not drop into the stigmatic basin, but alights on the stamens, the slender filaments act like the lip of *Calopogon* and let it down upon the stigma. It is, Robertson affirms, a matter of strength and endurance on the part of the insect whether or not it gets out alive. The fluid on the stigma seems to be intended to loosen the pollen grains from the scopae of the bees which have been collecting them on the older flowers. When the stigmatic fluid is absorbed, the pollen grains settle down among the papillae and are in a position to germinate. I have not, he says, discovered any sweet taste in the water, nor have I seen insects attracted by it. Moreover, it seems to be present in too great quantity for the purpose of nectar. Indeed, when the insects are thrown back repeatedly into it, they may be drowned. If Robertson's interpretation is correct, the flower is remarkable for having perfected a protogynous condition, although visited exclusively for pollen.

A list of insects found visiting the flowers is given by Robertson, and includes : Hymenoptera—ANDRENIDAE, 8 spp., of which 2 spp. were sometimes drowned; Diptera—SYRPHIDAE, 1 sp.; BOMBYLIDAE, 1 sp.; Coleoptera—RHIPIPHORIDAE, 1 sp., which was drowned.

Müller (9) and Knuth (7) both record a number of insect visitors to the flowers of *Nuphar luteum* Sibth. & Smith and *Nymphaea alba* Presl., and, of the latter species, Knuth states that the stigma secretes a moisture which is perhaps licked by insects, and that the flowers, owing to their aquatic habits, are accessible only to flying insects.

Many records exist of the insect visitors to the flowers of Nymphaeas, but such are not considered here as they deal with normal visitations and no mention is made of the death of the insect visitors.

Scott Elliot (12), in his " Notes on the Fertilisation of South African and Madagascar Flowering Plants," says of *N. stellata* (meaning *N. capensis*) " that the bright blue flowers are busily visited by bees," but makes no mention of dead insects in the stigmatic cup. Continuing, he states, " While the stamens are dehiscing, no pollen can be shed upon the stigma as the younger stamens are bent forward over them; afterwards, however, as the anthers ripen, they turn outwards exposing the stigmata."

Again, Scott Elliot (13), while mentioning the visits of *Bombus* (*lucorum ?*), *Apis, Scatophaga litorea* Fln., and Anthomyiids to the flowers of *Nymphaea alba*, makes no mention of untoward happenings to the visitors.

As to the hardy species of Water-lily which are grown in the ornamental ponds and pools at Wisley, we have no records of dead insects found in the flowers, while the number of insect visitors to the flowers of *Nymphaea Gladstoniana*, and *N. Marliacea* and its varieties, is comparatively small and these comprise some of the smaller Syrphids, with but few records of Hymenoptera.

Mr. H. M. Edelsten has kindly allowed me to state that he frequently noticed dead flies, chiefly Hover flies, dead in the open flowers of Water-lilies (*Marliacea* group) in his garden at Enfield. As many as five or six dead flies were found in a single bloom, and it was presumed that they were attracted by the presence of the Water-lily aphid. Mr. Edelsten mentioned the fact to Dr. F. W. Edwards, who suggested that the flies had gone to the Nymphaeas to die, having been attacked by fungus, and had not been attracted to the flowers by any other cause.

I am indebted to Dr. O. W. Richards for drawing my attention to an account of the poisonous effects of May-blobs (*Caltha palustris*) on Humble-bees. Morley (8) at Skelmanthorpe on the 13th May, 1917, found the flowers had attracted a number of Humble-bees with disastrous results to the visitors. He observed 8 *Bombus terrestris* and 4 *B. venustus* all dead or dying. One *terrestris*, less helpless than the others, was feebly thrusting her tongue amongst the stamens, and continued doing so for a few minutes, but eventually became listless and as defenceless as the others. A few Honey-bees, *Apis mellifera*, were also working the flowers, but they were never observed to use their tongues, and they appeared only to be collecting pollen by walking about over the anthers, but they suffered no harm. It is possible that the Humble-bees were affected in a manner similar to that produced by the flowers of *Tilia petiolaris*.

The Problem and the Solution.—Following the meeting of the R.H.S. Scientific Committee at which the collection of insects was shown, Mr. W. Hales of the Chelsea Physic Garden, mentioned the work of Dr. W. Rushton of the Biological Department of St. Thomas's Hospital Medical School, who had been carrying out investigations on the death of fish in ornamental waters containing Water-lilies. The suggested cause of death of the fish was that a glucocide was responsible.

As I was not convinced that the insects found dead in the Water-lily flowers were always drowned, or that they were asphyxiated or trapped, I wrote to Dr. Rushton on the 11th March, 1936. His reply (dated 12th March) was as follows :—" Every year from one source or another I get queries in regard to the death of fish in ornamental waters containing Water-lilies. The fish most affected are Goldfish, Bream, Roach and Perch. The trouble always seems to be either in small ponds or fairly extensive waters in parks where Water-lilies have become overgrown, and the dead and decaying leaves and leaf-stalks have been allowed to decay *in situ*. From my experience the trouble mostly occurs in late autumn or early winter, and it appears that a glucocide is exuded from the decaying plant debris. The fish at first appear very lethargic and slowly die off, not usually in large numbers at first, but just odd ones, and, if remedial measures are not taken the following year, if restocking has been carried out, the fish mortality is higher. I recall an occasion many years back when at Wanstead Park a few fish died off one autumn and the following year a larger number died. This went on for about three years during which time it had been clearly demonstrated that a gradual spread of Water-lilies had taken place coinciding with the fish mortalities. A careful and systematic thinning of the lilies was carried out and has been continued ever since, and for the last four years no adverse reports have come in. I think you are right in your contention that drowning is not the cause of the death of the flies, etc., and I am in agreement with you that they are possibly poisoned by the liquid which may contain a poisonous glucocide (may be a cyanide)."

Acting on Dr. Rushton's suggestion that a cyanide may be concerned with the death of the insects in the stigmatic fluid, a few c.cs. of the liquid were handed to my colleague Dr. M. A. H. Tincker, who very kindly tested it for a cyanide with the Picric acid–Sodium carbonate test, and obtained a negative result.

On the 17th July, 1936, some of the liquid (about 8 c.cs.) was sent to Dr. Rushton with the explanation that the supply was limited owing to the liquid being present only in the freshly opened flowers (1·2 c.c. average per blossom), and that it was absorbed in about 24 hours. One may find the liquid in about 7 flowers out of 40 open each day.

The results of Dr. Rushton's investigations were as follows :—

" 1. Tested chemically for glucose, and obtained a positive result.

" 2. Tested chemically for a cyanide, which is one of the chemical substances usually connected up with glucose in a plant glucocide, and got a negative result.

"3. Tried several specimens of *Cladocera* and *Bosmina*, and found that although the animals appeared a little active, it had no harmful effect on them. I used the crude liquid for these.

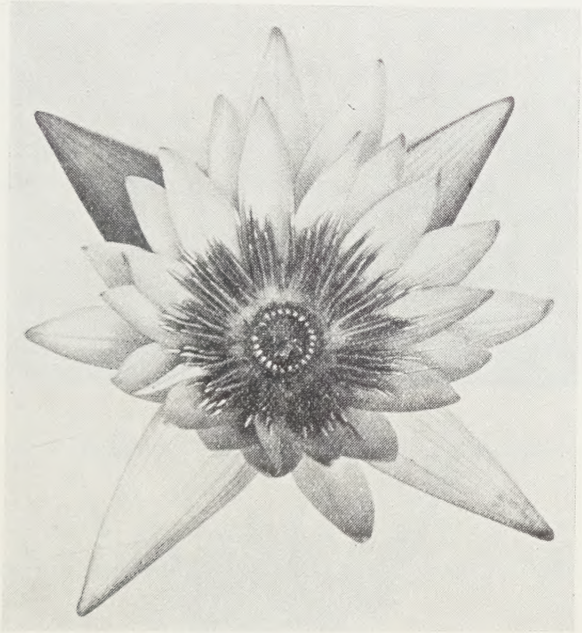

Fig. 1.—*Nymphaea capensis* flower in which a dead Drone fly (*Eristalis arbustorum* Linn.) appears in the stigmatic basin.

"4. Tried goldfish and minnows in the smallest amount of water these fish could live in plus some of the liquid sent. The dilution would be about 1 part liquid to 40 parts of water. The fish appeared a little lively at first but soon settled down behaving normally, and were alive 24 hours afterwards showing no signs of having been adversely affected by the liquid. The fish during the time they were subjected to the water plus liquid showed no signs of having been affected by any toxic substance. Some fish were tried by pouring some of the liquid direct on to the gills and into the mouth, and then liberated into water, but these fish survived even this drastic treatment.

"It would suggest that the action of the fluid on the flies is more likely to be due to a fermenting alcoholic liquid rather than a direct toxic action." (Letter dated 21st July, 1936.)

I then asked Dr. Rushton what alcohol was concerned, and in his reply (dated 27th July, 1936) he stated, "I doubt on such small quantities whether one could get what alcohol it would be, but I should think it would be ethyl alcohol, such as one gets with fermenting sugar with yeasts. Possibly some wild yeast or bacteria are the source of the enzyme."

List of Nymphaeas mentioned in the Text.

	Section.	Sub-Genus.	Distribution.	Colour of Flower.
N. capensis Thunb.	I. Apocarpiae	II. *Brachyceras*	S. & E. Africa, Madagascar	Sky blue
N. zanzibarensis Casp.	I. Apocarpiae	II. *Brachyceras*	Zanzibar	Deep blue
N. stellata Willd.	I. Apocarpiae	II. *Brachyceras*	India, Java	Sky blue
N. alba Presl.	II. Syncarpiae	III. *Castalia*	Europe, N. Africa	White
N. odorata Ait.	II. Syncarpiae	III. *Castalia*	Eastern U. States	White, with Red variety
N. tuberosa Paine	II. Syncarpiae	III. *Castalia*	N. Central U. States	White

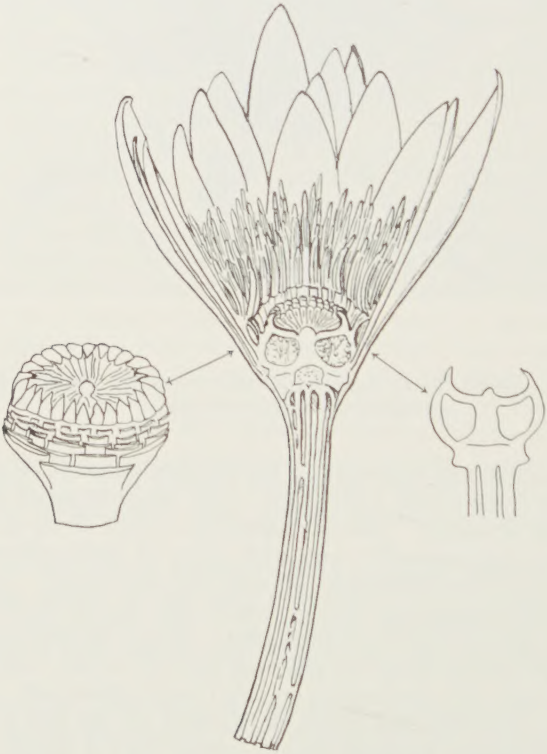

Fig. 2.—Anatomical structure of *Nymphaea capensis* flower showing numerous stamens, ring of carpellary styles, and stigmatic basin.
(By permission of the Council of the Royal Horticultural Society.

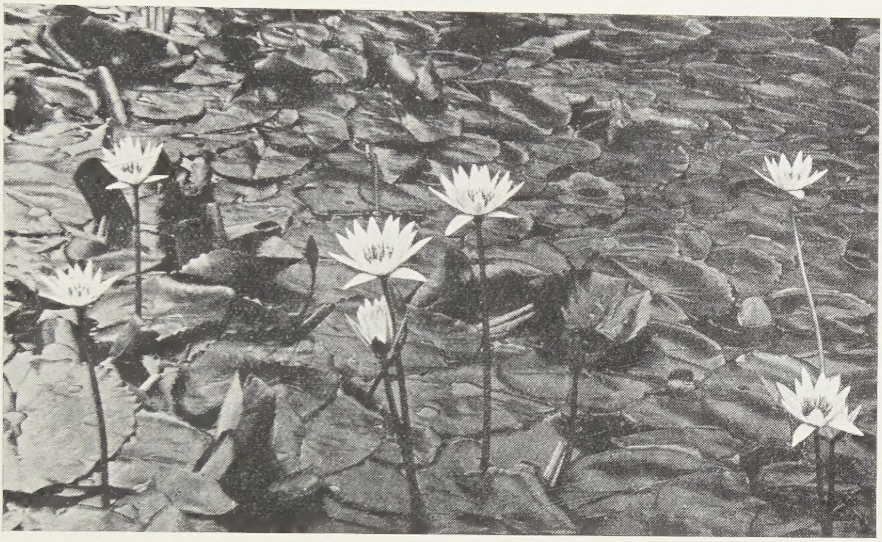

Fig. 3.—Newly opened (1) and older flowers (7) of *Nymphaea capensis* growing in heated tank.

Insects captured in the Flowers (14 blooms) of *Nymphaea capensis* Thunb. during August, 1935.

	♂♂.	♀♀.	Percentage of Total Captures.
Hymenoptera (4).			
Andrenidae.			
Halictus minutissimus Kirby	—	1	2
H. morio Fab.	—	1	2
H. zonulus Smith	—	1	2
Apidae.			
Stelis punctulatissima Kirby	1	—	2
Diptera (42).			
Syrphidae.			
Melanostoma mellinum Linn.	—	1	2
Syrphus auricollis Meig. var. *maculicornis* Zett.	—	4	8
S. balteatus De Geer	—	1	2
S. ribesii Linn.	1	1	4
Sphaerophoria scripta Linn.	—	1	2
S. menthastri Linn.	—	2	4
Eristalis arbustorum Linn.	9	19	61
Syritta pipiens Linn.	—	2	4
Callicera aenea F.	—	1	2

Captures made in 1936.

	Date.	♂♂.	♀♀.	Percentage of Total Captures in 1936.
Hymenoptera (15).				
COLLETIDAE.				
Prosopis communis Nyl.	17.viii. 24.viii. (2)	—	3	3·5
ANDRENIDAE.				
Halictus calceatus Scop.	22.vii.	1	—	1
H. laevigatus K.	24.viii. (2)	1	1	2
H. leucozonius Schrk.	17.viii.	—	1	1
H. minutissimus K.	13.vii. 24.viii. 18.ix.	—	3	3·5
H. morio Fab.	17.viii. 25.ix.	—	2	2
Andrena argentata Smith	17.viii.	—	1	1
APIDAE.				
Chelostoma campanularum K.	24.viii.	—	1	1
Heriades truncorum Spin.	17.viii.	1	—	1
Diptera (69).				
EMPIDAE.				
Empis aestiva Loew.	17.viii.	1	—	1
SYRPHIDAE.				
Liogaster metallina Fab.	27.vii. 17.viii. (4) 24.viii. (3)	—	8	9
Platychirus peltatus Mg.	24.viii.	—	1	1
Melanostoma mellinum Linn.	22.vii. (2) 27.vii (2) 5.viii. (6) 17.viii. (2) 24.viii. 25.ix.	1	13	16
Syrphus auricollis Meig. var. *maculicornis* Zett.	24.viii.	—	1	1
S. balteatus De Geer.	27.vii.	—	1	1
S. corollae F.	13.vii.	—	1	1
S. ribesii Linn.	4.ix.	—	1	1
Sphaerophoria menthastri Linn.	17.viii.	—	1	1
Ascia podogrica F.	11.ix.	—	1	1
Rhingia campestris Mg.	4.ix. (4) 11.ix. (2) 18.ix.	—	7	8
Eristalis arbustorum Linn.	13.vii. 4.ix. (3) 11.ix. (5) 18.ix. (4) 25.ix. (6)	7	12	22
E. sepulchralis Linn.	24.viii.	—	1	1
E. tenax Linn.	18.ix.	1	—	1
Syritta pipiens Linn.	17.viii. (4) 24.viii. (3) 11.ix.	1	7	9
ANTHOMYIDAE.				
Species undetermined	5.viii. 17.viii. 24.viii.	—	3	3·5
Coleoptera (2).				
NITIDULIDAE.				
Meligethes viridescens F.	22.vii.	—	2	2

ACKNOWLEDGMENTS.

I wish to acknowledge with sincere thanks the help I have received from Dr. F. W. Edwards, Mr. R. L. Coe and Mr. R. B. Benson, M.A., of the British Museum (Natural History), and from Dr. O. W. Richards of the Imperial College of Science, for their kindness in identifying the Diptera and Hymenoptera respectively; to Dr. W. Rushton for his valued reports and for his help in determining the nature of the fluid present in the stigmatic cup; and to my colleagues, Dr. M. A. H. Tincker, and Mr. F. C. Brown for drawing my attention to the phenomenon and for the photographs which illustrate this paper.

SUMMARY.

Observations carried out during the summers 1935–1936 on flowers of *Nymphaea capensis* Thunb. growing in a heated tank at the Royal Horticultural Society's Gardens, Wisley, Surrey, have shown that a number of pollinating insects (Hymenoptera and Diptera) are killed in the flowers. Death would appear to be due, at least in the case of the more robust insects (*Eristalis* and some other Syrphids), as a result of a fermenting alcoholic liquid in the stigmatic basin, and not entirely to a direct toxic action of the fluid nor, as some authors suggest, to mere drowning, to confinement by occlusion of the flower, to asphyxiation from the heavy odour of the bloom, nor to the accumulation of carbon dioxide in the floral cup.

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COLOUR VISION IN THE TRIUNGULIN LARVA OF A STREPSIPTERON (*CORIOXENOS ANTESTIAE* BLAIR)

By T. W. KIRKPATRICK, M.A., F.R.E.S.

(*East African Agricultural Research Station, Amani, Tanganyika.*)

Corioxenos antestiae is a species of Strepsiptera that has recently been described by Blair (1936). In the coffee plantations on the lower slopes of Kilimanjaro, Tanganyika Territory, it is a common parasite of *Antestia lineaticollis* Stal (PENTATOMIDAE), one of the most serious pests of Arabica coffee in East Africa. Since first finding this parasite early in 1935 I have been engaged on a study of its life-history, of which I hope shortly to publish a full account. Both the host and the parasite are extremely easy to breed in captivity; it has therefore been possible to obtain far more information about the bionomics of this species of Strepsiptera than has previously been obtained about any other member of this most interesting Order. The following notes on colour vision are concerned with one of the several remarkable phenomena that have come to light during the course of my investigations.

The free-living, first-instar larva of *Corioxenos*, which for convenience is called a triungulin,* is a minute shining black creature, 0·25 to 0·27 mm. in length and about 0·1 mm. broad. The two anterior pairs of legs are provided with tarsal empodia, which apparently secrete a sticky substance, since the triungulin can adhere instantly to any surface by any one of them. The tarsi of the posterior pair of legs are comparatively long and almost setiform. The ninth abdominal segment bears a pair of long slender bristles, and the tenth segment another pair of slightly longer bristles. These, the "central pair of tail-bristles," are 0·11 mm. long; at about 0·065 mm. from their base there is a swelling which is a reservoir for a sticky secretion from a pair of glands situated in the apex of the abdomen. The duct of this gland opens just beyond the reservoir. The terminal third of these bristles is exceedingly slender (much more so, in proportion to the basal two thirds, than is apparent from the accompanying figures). The triungulin has a pair of rather large lateral ocelli, but they are not conspicuous in the living insect.

When the triungulins have left their maternal host, they crawl about on whatever surface they happen to find themselves, normally some part of the coffee bush. Fig. 1 shows, diagrammatically, a triungulin in the walking position. They are by no means active insects, as the triungulins of some species of Strepsiptera are said to be, for their rate of progression seldom exceeds 4 mm. a minute, and they do not often crawl for more than 2 or 3 mm. without stopping and adopting what I have called the "waiting attitude." In order to adopt this position they grip with the two front pairs of legs, raise the abdomen high into the air, and bend the central pair of tail-bristles downwards and forwards under the abdomen, which is then lowered. They then let go with the two front pairs of legs and raise the body to an angle of about 40°. The anterior pair of legs is held projecting forwards at an angle of 45°, and the middle pair at right angles, to the body. When in this position (fig. 2) they are well adapted for fastening on to anything, whether it is an immature *Antestia*, i.e. a potential host, or some other object, that may happen to touch them. They are also capable of jumping a considerable distance, at least 10 mm. vertically and about 20 mm. horizontally. I have been unable to discover the exact method by which the jump is effected, for it takes place much too quickly for any detailed observation to be made. Either they let go with their hind legs and the central pair of tail-bristles act as a spring (somewhat in the same way that Collembola jump) or, more probably, propulsion is mainly caused by the hind legs. If the hind legs only were used for propulsion, I can see no reason for their invariably bending the tail-bristles under the abdomen, in the position shown in fig. 2.

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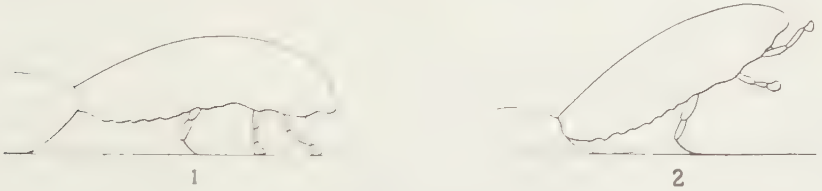
* Actually, as pointed out by Perkins (1905), the first-instar larvae of Strepsiptera lack the very feature—the three-clawed last tarsal joint—on which the word triungulin is founded. But there seems little to be gained by adopting any other term.

They have seldom been observed to jump unless stimulated to do so by the near approach of some object, and for this stimulus to have much effect, the object must be of certain colours.

This remarkable phenomenon was accidentally discovered in the following way. I had been watching, under a low-power binocular, some 50 triungulins on a coffee berry, hoping to observe the mechanism by which the jump was effected. For over half an hour not a single one jumped, but when I happened to bring the butt of a red-coloured pencil close to the berry, a large number immediately jumped on to it. After some preliminary experiments which disproved my first hypothesis, that they were attracted by the warmth of the pencil (which had been held in my hand), it became clear that they jumped far more often on to objects of certain colours. A fairly extensive series of observations were then made, whenever triungulins in sufficient numbers were available, the results of which are summarised in Table 1.



Figs. 1–2.—1. diagram of a triungulin walking; 2. diagram of a triungulin in the "waiting attitude." × 125.

There are certain difficulties in making precise experiments on their reaction to colours, since they are only able to jump when in the waiting attitude, and of those present in a given area, the number adopting this attitude will vary almost from second to second.

The surfaces from which, in the following experiments, triungulins were made to jump were mostly either green coffee berries or white paper, and in a few cases the glass plates covering the small containers in which the hosts were kept.

The method adopted was to move strips of coloured cardboard, 1 cm. wide, over a surface on which triungulins were present. The strips were held, as nearly as could be judged, 5 mm. above the surface and were moved at the rate of 1 cm. per second. As soon as a given surface had been traversed in this manner and the number that had jumped on to a certain colour had been counted, the same surface was gone over again in an exactly similar way with another colour. It was clear that having regard to the limited

TABLE 1.

Colour preferences of the triungulins of *Corioxenos.*

		Second Colour offered.											
		Violet-Red.	Orange.	Yellow-Orange.	Black.	Yellow.	Yellow-Green.	Blue.	Blue-Green.	White.	Total I.	Per cent. I.	Order I.
First colour offered.	Violet-Red					59 1	62 1	72 3	87 9	73 0	353 14	96	1
	Orange					108 6	173 7	42 10	37 0	23 0	383 23	94	2
	Yellow-Orange					43 5	31 5	23 2	36 0	61 1	194 13	94	3
	Black					53 7	25 5	37 8	34 0	32 0	181 20	90	4
	Yellow	61 68	78 119	23 21	31 25		37 4	30 14	14 5	14 1	288 257	53	5
	Yellow-Green	25 38	61 95	23 15	40 44	26 4					175 196	47	6
	Blue	20 61	45 30	22 51	29 42	21 7					137 191	42	7
	Blue-Green	35 169	15 61	41 41	6 55	17 7					114 333	25	8
	White	16 142	8 49	12 54	2 62	9 21					47 328	13	9
Total II		157 478	207 354	121 182	108 228	336 58	328 22	204 37	208 14	203 2	1872 1375		
Per cent. II		77	63	60	68	15	6	15	6	1			
Order II		1	3	4	2	5	7	6	8	9			

The upper figure in each square is the number of triungulins that jumped on to the colour shown on the left of the table, that colour having been offered first; the lower figure is the number that subsequently jumped on to the colour shown at the top of the table.

The column headed "Per cent. I" shows the percentage (of the total attracted to all colours offered) that jumped on to the colour first offered. Similarly, "Per cent. II" shows the percentage attracted at their second chance to the colour at the top of the table, after they had failed to jump on to the colour first presented.

"Order I" and "Order II" show the order of preference for each colour, when offered as first and second choice respectively.

time available and a not inexhaustible supply of triungulins, in order to make experiments with as many as possible combinations of pairs of two colours, the number of colours must be limited; choice of colours for the experiments was also restricted to some extent by what was available. The colours chosen were as follows, orange and black being selected because these are the prevailing colours of *Antestia*. (In brackets is given the exact name and description according to Ridgway (1912).)

(1) Violet-Red. (Spinel Red, 71′. V–RR.)
(2) Orange. (Orange Chrome, 11. O.)
(3) Yellow-Orange. (Light Cadmium, 19. YO–Y.)
(4) Black.
(5) Yellow. (Lemon Yellow, 23. Y.)
(6) Yellow-Green. (Viridine Green, 33d. GY–G.)
(7) Blue. (Spectrum Blue, 49. B.)
(8) Blue-Green. (Methyl Green, 41′. BB–G.)
(9) White.

All these colours had a dull surface. A few trials were made to compare a dull with a shining red and orange, but no difference in attractiveness was apparent. Nor was there any difference when the coloured cardboard was covered with glass.

The figures in each square of Table 1 represent the totals of triungulins attracted, the upper figure to the colour first presented and the lower figure to the colour subsequently presented. The number of tests made with each pair of colours ranged from two to six, since the total number of triungulins jumping from any one group naturally varied. It was aimed to get a total of between 50 and 100 jumping on to each of the 48 combinations of colours, but this was not quite achieved in every case, though in many it was considerably exceeded.

The top right-hand corner of the table gives the number of triungulins that jumped on to the more attractive colours when these were offered first, and on to the less attractive ones when they were offered second. The lower left-hand corner shows the number that jumped on to the less attractive colours when offered first and on to the more attractive when offered second. Since each colour was offered an equal number of times both as first and second choice, a possible objection, namely that the triungulins tend to jump to the first object offered, or conversely that the first object rouses them and they tend to jump to the second, irrespective of colour, is therefore disposed of.

While there is probably no significant difference in the attractiveness of Violet-Red, Orange, Yellow-Orange and Black, all of which when offered as first choice attracted 90% or more of the available triungulins, and 60% or more when offered as second choice, it is clear that these colours are far more attractive than Yellow, Blue, Green and White.

In addition to the foregoing a few experiments were made using natural objects—red and orange flowers and blades of grass. These were not very exact, since the size of the objects varied somewhat, but red and orange flowers were found to be more attractive than green grass. In some trials with a strip of a bright green leaf, compared with a strip of green cardboard of equal size, the leaf was found to be considerably more attractive than the very non-attractive green cardboard.

If one of the attractive colours was slowly lowered towards a number of triungulins, a few were sometimes observed to attempt to jump on to it while it was still about 15 mm. distant, and therefore just beyond their reach. In these cases they landed again on the surface from which they had jumped.

There is no doubt that the triungulins can perceive the non-attractive colours, for I have watched them under a microscope while a white object was slowly being brought near. As soon as it gets within range, about 10 to

15 mm., they make swaying movements with their body, but these usually cease after a few seconds, even though the object is still held close to them. When the object is of one of the attractive colours they make one or two similar swaying movements and then jump.

This attraction for certain colours is only apparent with reference to jumping on to a moving object, the triungulins do not seem to have any preference for walking or resting on a particular colour. A large number was placed in the (white) centre of a cardboard circle, which was divided into differently coloured segments. After twenty four hours, to allow the triungulins time to move away from the centre, the numbers on each colour were counted, but no significant difference was found. Admittedly this is an unsatisfactory experiment, since the triungulins could have no knowledge of the colours in the adjacent segments, but it might have been thought that they would tend to keep moving until they came by chance to an attractive colour. They do not, however, appear to do so.

Similarly, when walking, they will take no notice of the proximity of any object. Even the close approach of an object of the most attractive colour will not cause them to stop, assume the waiting attitude, and jump.

It is probable, though the number of experiments required to prove it would be very large, and insufficient have been made, that they jump less readily *from* an attractive colour than from a non-attractive one. If this is so, presumably it is because fewer of them adopt the position in which jumping is possible, when they are on an attractive colour. (All the observations on which Table 1 is based are on triungulins that jumped from a non-attractive colour, either a green coffee berry, white paper, or glass.) I have, however, made one individual jump four times in quick succession from a red to an orange object and back again. But after four jumps it seemed to be tired and refused to play any more!

It will be observed that the attractive colours, Orange, Red and Black, are all at the long-wave end of the spectrum, at least if it be assumed that black tends to reflect infra-red rays. What is perhaps more significant is that two of the most attractive colours, namely black and orange, are the predominant colours of *Antestia* nymphs. As Eltringham (1933) has remarked, "Many insects would appear to have no use for a sense of colour and Nature rarely lavishes useless gifts on her offspring. If a colour sense be present at all we should naturally look for it in species which are associated with colour, either in themselves or in their normal surroundings, or both."

There can be little doubt that the faculty that the triungulins of *Corioxenos* have of distinguishing colours is of direct benefit to them by tending to increase the number of individuals that succeed in attaching themselves to a potential host. Eltringham opens his chapter on colour vision with the question, "Can insects distinguish colours?" This can most certainly be answered in the affirmative as regards the triungulins of *Corioxenos*.

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ON A GYNANDROMORPHOUS *FORFICULA AURICULARIA* L.

By M. A. H. Qadri.
(*Entomology Dept., Zoological Laboratory, Cambridge.*)

Communicated by Dr. A. D. Imms, F.R.S., F.R.E.S.

Gynandromorphism in earwigs is known to occur in a number of species, including *Labidura riparia* Pall., *Chelisoches morio* Fab., *Forficula auricularia* L. and others. In *F. auricularia* L. it has been recorded by Perty, Paoli and Chopard.

Perty (1866) reported a case of a gynandromorphous *F. auricularia* in which the right calliper was of the male type and curved, while the left calliper was straight and of the female type. Paoli (1906) recorded and figured another case of gynandromorphism in this species. In an example measuring 17 mm. long, the left calliper was of the male type and measured 4·5 mm. long. It bore the characteristic basal denticles and was prominently curved. The right calliper measured only 3 mm. long and while it bore a resemblance to the female type of organ, it was more prominently curved towards the apex and was non-crenulated basally. A very similar abnormality is described and figured by Chopard (1912) in an example of *F. auricularia*, whose body length was 10 mm. and whose longest calliper measured 4 mm. In this case the right calliper (4 mm. long) was of the male type, except that the basal denticles were but little developed. The left calliper differed from such an appendage in a normal female not only on account of being much shorter, but also from the fact that it was more incurved and non-crenulated basally. Chopard's specimens showed typical well-developed male gonads with the aedeagus normal. The observer pointed out that the left calliper resembled that of a young female individual.

The present case of a gynandromorphous *F. auricularia* is interesting and shows certain features apparently not hitherto recorded in any of the earwigs. The specimen was collected from Epping Forest by Mr. Hugh Main during March 1936, and was given to Dr. A. D. Imms, who has assisted me during the preparation of this note. Except for the gynandromorphic features to be mentioned there is no other variation in the body-structure of the earwig. The 10th tergum and 9th sternum are present in typical form. The 11th tergum or pygidium is curiously modified. In a normal male this plate has each of its postero-lateral angles produced in the form of a short conical process, whereas there are no such processes present in a normal female. In the present form the right postero-lateral angle is provided with a process and is therefore typically that of a male. The left postero-lateral angle is devoid of a process and consequently shows a female character. Along with these modifications, there is a small projection in the middle of the posterior margin of the 11th tergum both on the dorsal as well as on the ventral side of it. This is a feature which is present neither in the typical male nor female.

The two forceps or callipers greatly differ from each other. The left calliper is like that of a typical male. It is strongly arched and is provided with heavily sclerotised teeth at the base. The right calliper is like that of a female. It is developed to its full length and is not arched like the left one. The basal teeth are absent but the inner margin is, however, strongly sclerotised, irregular near the base and crenulated, though not as typically as in a normal female.

In the cases recorded and figured by Paoli and Chopard, as described above, the right calliper, which is mentioned as of female type, shows a great difference from the normal female calliper. It is not developed to its full length, while it is slightly incurved and is devoid of basal crenulations. The right calliper in the present specimen is more or less of the female type. It is fully developed in length and is not incurved as in the alleged female type of calliper of the above-mentioned cases reported by Paoli and Chopard. The basal crenulations are also present, whereas they are reported to be absent in former cases. Nothing is known about the details of the callipers in the form reported by Perty, who did not figure his specimen.

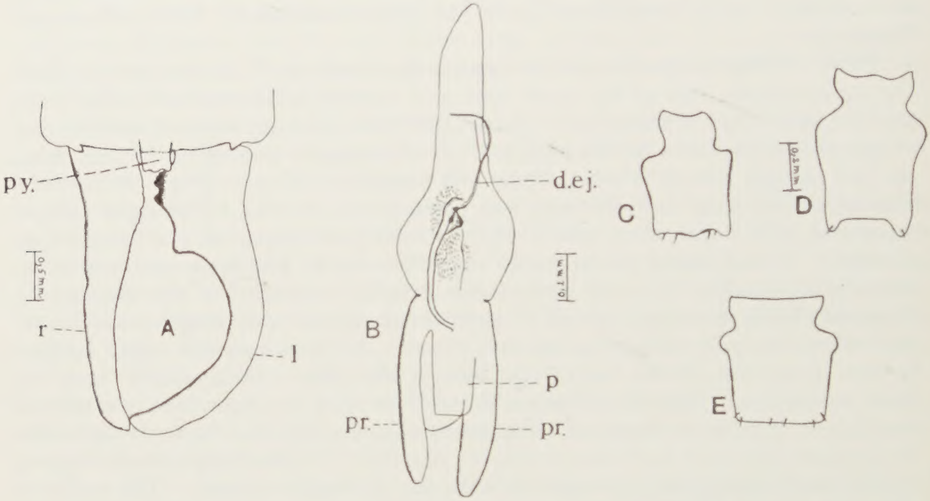

Fig. 1.—*Forficula auricularia.* *A*, ventral view of hind extremity of abdomen of gynandromorph. *l* and *r*, left and right callipers ; *py*, pygidium. *B*, ventral view of pygidium of gynandromorph. *C*, do. of typical male. *D*, do. of typical female. *E*, ventral view of genitalia (male) of gynandromorph. *p*, penis ; *pr*, parameres ; *ej*, ejaculatory duct.

The external genitalia in the present example are those of a male. There is a median penis and two lateral processes or parameres. The right paramere is somewhat shorter and distally thinner than the left one and appears to be definitely affected by gynandromorphism. In the normal case, as figured by Burr, Walker and Snodgrass, the lateral processes or parameres are of equal size.

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BUNGAY, SUFFOLK.